VERIFICATION AND CERTIFICATION SAMPLING AND ANALYSIS FOR CLEANUP TO "XXXXX" STATUS OF MATERIALS FROM EXPLOSIVES WASHOUT PLANTS

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ABSTRACT

A sampling and analysis program was developed for the Umatilla Chemical Depot (UMCD) Explosives Washout Plant to verify and certify the decontamination of materials to the U.S. Army "XXXXX" (5X) status. Based on U.S. Army policy, materials contaminated with energetic substances that are released to the public are required to meet a U.S. Army 5X status. This classification is typically applied to items that have undergone decontamination by thermal treatment, although under special circumstances, other methods may be acceptable as long as elimination of the explosives safety hazard can be attained and demonstrated.

The objective of the verification and certification sampling program was to obtain a high degree of certainty that treatment to a U.S. Army 5X status was attained and use cost-effective field tests to the maximum extent possible. Verification sampling refers to analytical testing that was performed to verify that treatment was complete; certification sampling refers to analytical testing that was performed to certify that materials were decontaminated to specified cleanup objectives.

Tests were selected based on their ability to detect nitroaromatic and nitroamine compounds, primarily 2,4,6-trinitrotoluene (TNT) and hexahydro-1,3,5-trinitro-1,3,5-triazine (commonly referred to as Research Department Explosives or Royal Demolition Explosives or RDX), and their ease of use. Field tests evaluated included qualitative colorimetric tests (Webster's Reagent, Diphenylamine Reagent, and Thymol Reagent), quantitative colorimetric tests (EPA Methods 8510 and 8515 or Jenkins' Method), Certipaks, and EPA Method 8330. For materials cleaned by low flow, high pressure, hot water washing, Webster's Reagent was selected as the verification test and EPA Methods 8510 and 8515 was selected for the certification tests. For materials treated by flaming, Certipaks were selected for the verification test and EPA Method 8330 was selected for the certification test.

The verification and certification program included developing a sampling scheme based on the surface area of material treated and degree of difficulty to treat the material. Building materials and equipment which were considered more difficult to treat were assigned a higher frequency of sampling. A review of the field implementation of the verification and certification sampling and analysis program is presented.

INTRODUCTION

UMCD is a United States (U.S.) U.S. Army ordnance depot which has been slated for realignment under the Department of Defense (DoD) Base Realignment and Closure (BRAC) program. The facility is expected to be released to public or private interests for other uses, including, but not limited to, either light industrial or residential use.

Due to the historical activities at the site, environmental investigations were conducted to identify areas of concern, characterize site conditions, and define the nature and extent of contamination (Dames & Moore 1990 and 1992). Several operable units at UMCD were identified for remedial action, including the Explosives Washout Plant which processed munitions, bombs, and projectiles to remove and recover explosives using a hot water system. The Explosives Washout Plant was identified for decontamination and demolition.

Based on U.S. Army policy, materials contaminated with energetic substances that are released to the public are required to meet a U.S. Army 5X status.

Presented at and Published in Conference Proceeding for the
American Defense Preparedness Association
23rd Environmental Symposium and Exhibition, April 7-10, 1997
New Orleans, Louisiana

This classification is applied to items where no significant amounts of explosive chemicals exist that would present an explosive safety hazard. This material may be welded, drilled, sawed, etc., and may be sold to the general public (AMCOMM 1995). This classification is typically applied to items that have undergone decontamination by thermal treatment, although under special circumstances, other methods may be acceptable as long as elimination of the explosives safety hazard can be attained and demonstrated (AMCOMM 1987). This paper presents the sampling and analysis program designed to verify and certify decontamination of materials from the Explosives Washout Plant to the U.S. Army 5X status.

SITE HISTORY AND EXPLOSIVES WASHOUT PLANT OPERATIONS

UMCD is a 19,728-acre military facility located in northeastern Oregon, on the border of Morrow and Umatilla counties. The installation was established as a U.S. Army ordnance depot in 1941. From the mid-1950s until mid-1960s, UMCD operated an onsite Explosives Washout Plant. In the mid-1950s, the original building was burned for renovation and equipment modernization, and a new building was constructed at the same site. The plant processed munitions, bombs, and projectiles to remove and recover explosives using a hot water system. The plant consisted of two adjoining buildings (the washout building and pelletizer building) and a shed. The Explosives Washout Plant and equipment layout are shown on Figure 1.

The washout building was a large single story building in which the washout operation occurred. It consisted of an open bay with corrugated, galvanized steel walls, a poured concrete floor, and a corrugated, galvanized steel roof. The building was 81 feet (ft) by 32 ft and 31 ft high. The equipment in the washout building included a washout tank, settling tank, circulating tank, exhaust stack, water circulating system (including heat exchangers), overhead hydraulic crane, eductor system, pumps, and hot water tanks (located outside to the north of the building).

The pelletizer building contained equipment to separate, pelletize, and dry recovered explosives. This two-story building was attached to the washout building and shared a concrete blast wall with the washout building. The remaining three walls of the pelletizer building were constructed of corrugated aluminum sheet. The building was 32 ft by 22.5 ft and 25 ft high. The floors in both stories were constructed of poured concrete. The process equipment included a tank separator, Dopp kettle, pelleting tank (or pellet making tower), pellet dewatering screen, and a pellet dryer.

The facility recovered explosives in a batch mode process. Some of the munitions demilitarized at the plant included 500- and 700-pound Composition B bombs and 90-millimeter (mm) projectiles. Composition B is a mixture of 39 percent TNT, 60 percent RDX, and 1 percent desensitizer (wax). Besides composition B, the washout operations processed sizable amounts of TNT and tritonal (80 percent TNT with 20 percent aluminum flake). In addition, the following small amounts of explosives were likely present: octahydro-1,3,5,7-tetranitro-1,3,5,7-tetrazocine (commonly referred to as HMX); 2,4-dinitrotoluene (2,4-DNT); 2,6-dinitrotoluene (2,6-DNT); 1,3-

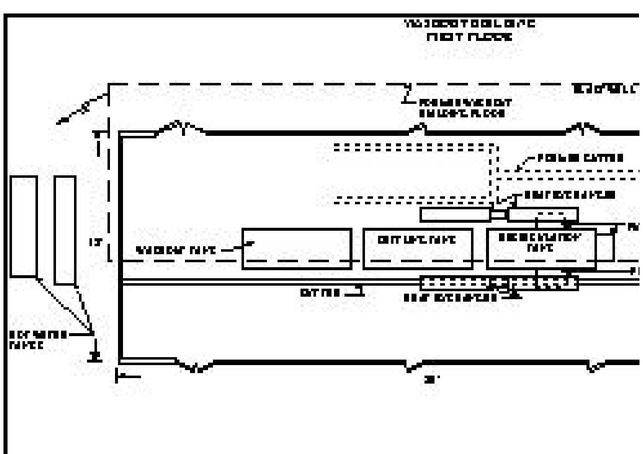

Figure 1: Explosives Washou

dintrobenzene (DNB); and nitrobenzene (NB) (A.D. Little 1993).

Bombs or projectiles were loaded into the washout tank and secured on racks. Hot water was sprayed into the base of the bombs to melt and washout the explosives. The water-entrained explosives were collected in the bottom of the washout, settling, and circulation tanks and pumped by a steam eductor to the separator tank located on the second floor of the pelletizer building. The explosives were separated and settled from the carrier water, and the carrier water was returned to the washout tank. The explosives were fed from the separator tank to the Dopp kettle to be heated and thoroughly mixed. The explosives were then fed to the pelletizer tank. The pelletized explosives were discharged to a vibrating screen for dewatering. The dewatered pellets were dropped into the dryer. The dried pellets were removed from the dryer on a conveyor system for packaging.

During operations, the Explosives Washout Plant was very dusty, in particular, the first floor of the pelletizer building where operations took place. The floors, walls, and exterior of the equipment were washed down daily with hot water at a temperature of approximately 100 degrees Celsius (°C) when the plant was in operation. After processing each batch of munitions, the process piping and tankage was flushed with hot water (McCoy 1994). Washwater was discharged along an open steel overflow trough with a sump located approximately midway between the plant and two infiltration lagoons. The Explosives Washwater Sump was constructed of concrete with two cells separated by a concrete wall and had a concrete bottom. The sump was approximately 20 ft long and 7 ft wide.

Sludge/sediment which accumulated in the sump was periodically transported to the Ammunition Demolition Activity (ADA) area, where it was burned in large open trays. Periodically, the residues in the sump were also burned in-situ (McCoy 1994). The sludge/sediment that remained in the sump had been exposed to the atmosphere for approximately 30 years since processing ceased.

REMEDIAL ACTION

The primary remediation technologies used for decontaminating the Explosives Washout Plant are low flow, high pressure, hot water washing and flaming. Low flow, high pressure hot water washing involves spraying water at high pressure into piping and the interior of equipment to mobilize, dissolve, and rinse out contamination. This technology involves using high temperature water to physically remove and solubilize contaminants from building and equipment surfaces.

Flaming involves subjecting contaminated building materials, equipment, and piping to fire and high temperatures until residual explosive contamination is decomposed or volatilized. Two types of flaming operations were implemented, open burning and contained burning. Flaming by open burning involves subjecting materials to an open fire on a concrete burn pad. Flaming by contained burning involves subjecting the Explosives Washwater Sump to fire and high temperature by containing a fire within the sump.

The major components of the remedial action which were implemented at the Explosives Washout Plant included:

- Removal of the pigeon remains in the plant by scraping
- Wiping the exterior of the asbestos piping insulation with soapy water, and disposal of asbestos insulated piping at an offsite hazardous waste landfill
- Pretreatment of process equipment and building structural steel to be flamed by low flow, high pressure, hot water washing and pretreatment of piping by water flushing
- Decontamination of the process equipment, uninsulated piping inside the building, part of the building structural steel, and other building materials with intricate surfaces by flaming using open burning
- Decontamination by low flow, high pressure, hot water washing of other building materials, including metal siding; concrete blast wall and flooring; roofing; structural steel which was not flamed; electrical conduits; overhead hydraulic crane assembly; external platforms, chutes, and stairs; hot water tanks; and exterior piping
- Removal of the sludge/sediment from the sump and burning it at the ADA area, followed by solidification/stabilization of the ash
- Flaming the sump and pigeon droppings by burning the sump in-place (or "contained"

burning), and disposal of ash sump concrete at the onsite landfill

- Excavating contaminated soil beneath the sump and plant; treatment of soil by solidification/stabilization
- Offsite disposal of decontaminated metal material as scrap
- Disposal of the treated sludge/sediment and concrete blast wall flooring at the onsite landfill
- Collection and onsite treatment and disposal of wastewater generated by decontamination processes by granular activated carbon (GAC) and onsite disposal; treatment of the GAC at an offsite thermal facility
- Collection and treatment of residual explosive contaminated solids generated by the water washing processes by open burning at ADA area
- Collection and onsite disposal of ash from equipment flaming and from residual contaminated solids open burning at the ADA area

DESCRIPTION OF VERIFICATION AND CERTIFICATION ANALYTICAL TESTING METHODS

This Section describes the potential types of verification and certification analytical testing methods for the Explosives Washout Plant remediation and the potential applicability of those methods.

Colorimetric Tests

Colorimetric tests use chemical reagents to test for the presence of explosive compounds. A variety of colorimetric tests have been developed (Fedoroff 1960). Colorimetric tests are performed by applying a small amount of one or more chemical reagents to the potentially contaminated material. The reagent is typically applied with an eye dropper or laboratory squeeze bottle. If the surface is contaminated, a color change should be apparent.

A review of colorimetric tests was performed to determine the tests most applicable for this field application. The tests were evaluated based on their ability to detect TNT and RDX and the simplicity of the test procedures. Test procedures that included sequential application of chemical reagents or heating were not considered. Verification sampling of materials decontaminated by low flow, high pressure, hot water washing required the test to be performed quickly and easily. The colorimetric tests which were evaluated included: Webster's Reagent, Diphenylamine Reagent, and Thymol Reagent.

Webster's Reagent is a particular formulation of an Alkali Hydroxide Reagent. Alkali Hydroxide Reagent is prepared with 5 to 10 grams of potassium hydroxide or sodium hydroxide in 100 milliliters (mL) of alcohol or water. Webster's Reagent is a solution of 5 percent potassium hydroxide in ethanol. Many nitroaromatic compounds produce color reactions with Webster's Reagent. The reagent becomes pink or red, if the surface tested is contaminated with DNT or TNT. Webster's Reagent does not produce a colorimetric change with nitroamine compounds, such as RDX (Fedoroff 1960). This reagent is currently used at U.S. Army facilities for analysis of TNT (Williams 1995).

Diphenylamine Reagent tests for the presence of RDX and is currently used at U.S. Army facilities (Williams 1995). Diphenylamine Reagent is prepared by dissolving 1 gram of diphenylamine ($C_6H_5NHC_6H_5$) in 100 mL of concentrated sulfuric acid. The reagent becomes deep green/blue if the material tested is contaminated with RDX. This reagent also has a slight colorimetric reaction with TNT, producing a faint yellow (Fedoroff 1960).

Thymol Reagent tests for the presence of TNT and RDX. It is prepared by dissolving thymol in concentrated sulfuric acid. The surface becomes yellow if TNT is present or deep red if RDX is present (Fedoroff 1960).

The sensitivity of Webster's Reagent, Diphenylamine Reagent, and Thymol Reagent were tested by Dr. Thomas Jenkins at the U.S. Army Cold Regions Research and Engineering Laboratory (CRREL) in May 1995. The sensitivity of these reagents were tested on unpainted aluminum and steel.

Webster's Reagent showed an instantaneous, evident colorimetric change to red for TNT on both aluminum and steel surfaces. A concentration as low as 2 micrograms per square centimeter ($\mu g/cm^2$) was detected, which is lower than the cleanup level of 4.6 $\mu g/cm^2$. It is likely that it would be equally effective on painted surfaces, with the exception of red painted surfaces, since the colorimetric change is red.

Diphenylamine Reagent was tested to evaluate its sensitivity as a colorimetric indicator for RDX. The Diphenylamine showed an evident change to blue on an aluminum surface at a RDX concentration as low as 10 $\mu g/cm^2$, which is greater than the cleanup level of 3.5 $\mu g/cm^2$. The sensitivity of Diphenylamine Reagent for detecting RDX on steel surfaces was less sensitive than on aluminum because there was a reaction of the reagent with the steel. There may be methods to increase the detection limit of the reagent, such as wiping a 100 cm^2 area of surface with a 10 cm^2 size glass fiber filter paper to concentrate the explosives on the filter paper (i.e., a 10 to 1 concentration).

Thymol Reagent produced a colorimetric change when it was applied to a mass of 0.05 grams of TNT or RDX, as documented by Fedoroff (1960). Thymol Reagent is ineffective as a colorimetric test for RDX and TNT for this field application, because the sensitivity of this test is 20 to 30 times higher than the cleanup levels. Thymol Reagent did not result in a colorimetric change for RDX or TNT at concentrations less than 100 $\mu g/cm^2$.

Colorimetric tests were considered applicable for use as verification sampling of nonporous materials decontaminated by low flow, high pressure, hot water washing. Of the three colorimetric tests presented, Webster's Reagent was recommended for the following reasons: it is sensitive to TNT concentrations near the cleanup level; and the reagent is composed of ethanol, which is less hazardous to workers than sulfuric acid that is used in both Diphenylamine Reagent and Thymol Reagent.

In addition, although Webster's Reagent does not produce a colorimetric change for RDX, the available analytical data indicated that TNT and RDX were jointly present in the sampled media, with the exception of samples with concentrations that were less than the cleanup levels and near the reporting limit. Therefore, verification testing for TNT only was sufficient to determine if explosives were present at concentrations above the cleanup levels and if retreatment was necessary.

EPA Method 8330

EPA Method 8330 uses High Performance Liquid Chromatography (HPLC) to analyze for specific nitroaromatic and nitroamine explosive compounds. The method reporting limits for each analyte are specific to the analytical laboratory. However, the reporting limits for TNT and RDX are significantly less than the concentration that was used to certify the material as decontaminated.

EPA Method 8330 was considered applicable for certification of potentially highly contaminated materials treated by flaming.

Certipaks

Certipaks are designed to demonstrate that known explosive contamination has been treated to 5X standards. Certipaks have been used to successfully verify that TNT, nitrocellulose (NC) and DNT contamination have been decomposed at Alabama U.S. Army Ammunition Plant (Rockwell International 1982) and the West Virginia Ordnance Works (USATHAMA 1988).

Certipaks are composed of ceramic beads impregnated with a known concentration of the contaminant of concern such as TNT, RDX, or HMX. Because flaming operations may not generate heat evenly throughout the equipment, Certipaks are typically placed in "cold spots," or areas that may be difficult to heat sufficiently to achieve decontamination. Insufficient heating can occur in areas where a lack of air circulation may prevent sufficient burning, or in areas on the perimeter of the burn where treatment temperatures may be reduced. Certipaks are also typically placed where high levels of explosives contamination is known or suspected to exist. After flaming, a colorimetric test is performed on the ceramic bead. If the contamination previously in the bead cannot be identified with the colorimetric test, verification of decontamination is achieved. If the colorimetric test indicates that decontamination was not achieved, new Certipaks are placed in the potentially untreated area and the flaming operation by open burning is repeated.

The ignition temperature is the lowest temperature at which combustion begins and continues when a substance is heated in air. The ignition temperatures for the contaminants of concern are as follows (Yinon and Zitrin 1981):

- TNT: 295°C - 300°C
- HMX: 279°C - 281°C
- RDX: 229°C

These ignition temperatures are in the same range as the thermal decomposition temperatures which range from 210°C to 280°C (Caulder 1995). Since

TNT has the highest ignition temperature, Certipaks were specified to be only impregnated with TNT and a colorimetric test specific to TNT was used. Where the colorimetric test indicated that TNT was decontaminated, it was assumed that HMX and RDX were also treated, because their ignition temperatures are lower.

The following discussion describes how Certipaks are constructed, tested, and retrieved. The porous ceramic bead used in a Certipak is donut shaped with a diameter of approximately 0.5 inches and a thickness of approximately 0.25 inches. The ceramic beads are soaked in a 6.0 mg/L solution of TNT in acetone for one or more hours. The beads are then air dried for four hours on an inert surface. The ceramic beads are then enclosed in a protective foil to prevent direct contact with soot or flame. Discoloration of the bead resulting from soot or direct exposure to smoke or flame renders it damaged, because the colorimetric test is ineffective. An envelope is constructed by folding and stapling a rectangular piece of stainless steel foil approximately 3 inches by 3.5 inches. An identification number is engraved on the stainless steel foil prior to the construction of the envelope. The ceramic bead is tied to a stainless steel wire prior to inserting the bead inside the envelope. After the bead is placed inside the envelope, the envelope is stapled shut. The size of the Certipak is approximately 1.25 inches by 2 inches.

After the Certipak is exposed to the flaming operation, the foil envelope is cut away. The ceramic bead should appear white or light grey in color. If the ceramic bead is covered in soot, the bead cannot be field tested.

Two reagents were used to field test for the presence of TNT. Reagent A consists of a 10 percent solution of tetraethylammonium hydroxide in water. Reagent B consists of 2 percent fluorene in dimethyformamide (DMF). Reagent B is prepared by diluting 50 mL of DMF for each gram of fluorene. A drop of Reagent A is place on the bead and sufficient time is allowed for the liquid to adsorb into the bead. A drop of Reagent B is placed at the same location where Reagent A adsorbed into the bead. If TNT is present, a blue color should immediately appear. Because the blue color may fade quickly, results should be documented immediately after Reagent B is placed on the bead (Rockwell International 1982).

Certipaks may be difficult to retrieve for testing after flaming because the materials being treated may collapse and melt. Therefore, each Certipak was specified to be equipped with a stainless steel wire of sufficient length to trace the location of the Certipak after the flaming operation. To assist in the recovery of Certipaks, the location of each Certipak was required to be documented prior to the flaming operation.

EPA Methods 8510 and 8515 (Jenkins' Method)

EPA Method 8510 and 8515 are EPA field analytical methods for analyzing RDX and TNT, respectively. These methods are colorimetric methods which use standard chemical reagents and a field spectrophotometer. EPA Method 8510 and 8515 are currently available as commercial test kits.

These field analytical methods were used to certify that earth moving equipment was sufficiently decontaminated for demobilization for the Phase I explosives soils remediation at UMCD. Testing was performed by collecting wipe samples from the equipment and conducting an analysis of the wipe samples.

Analysis of the wipe samples required a modification of EPA Method 8510 and 8515. Wipe sampling was performed using an acetone wetted 10 cm by 10 cm wipe. The equipment area was wiped using a 100 cm^2 template once in an up-and-down direction and once in a side-to-side direction. The wipe sample was then placed in acetone, agitated for 1 minute, and allowed to soak for 10 minutes to extract the explosive chemicals. The extract was then tested in accordance with EPA Method 8510 and 8515 test methods (Wakeman 1994). The threshold action level for the equipment was 46 $\mu g/cm^2$ (or 4.6 mg/100 cm^2) TNT.

Based on the previous application of EPA Methods 8510 and 8515 at UMCD, these analytical methods were considered applicable for certification of nonporous equipment and building materials that were treated by low flow, high pressure, hot water washing.

VERIFICATION AND CERTIFICATION SAMPLING AND ANALYSIS PROGRAM

This Section provides a description of the verification and certification sampling and analysis program for decontamination of the Explosives Washout Plant materials to a U.S. Army 5X status. A summary of the program is provided in Table 1.

Table 1: Verification and Certification Sampling and Analysis Program Summary

Media	Treatment Method	Verification		Certification	
		Method	Sample Frequency	Method	Sample Frequency
Open surfaces inside of buildings; walls on the exterior of buildings	Low flow, high press. hot water washing	Webster's Reagent Test	100 sf	EPA Method 8510 and 8515	1,000 sf
I-beams and trusses in washout building; electrical equipment enclosures; stairs, platforms, chutes outside buildings; hot water tanks; outside building lighting fixtures	Low flow, high press. hot water washing	Webster's Reagent Test	100 sf	EPA Method 8510 and 8515	500 sf
Roof on the outside of buildings	Low flow, high press. hot water washing	Webster's Reagent Test	100 sf	EPA Method 8510 and 8515	800 sf
Overhead hydraulic crane assembly	Low flow, high press. hot water washing	Webster's Reagent Test	25 sf	EPA Method 8510 and 8515	100 sf
Process equipment; steel trough; interior plant equipment; ducting; uninsulated piping; structural steel, except I-beams and trusses in washout building; non-secured misc. material	Flaming by open burning	Certipaks	27 cf	EPA Method 8330	135 cf

Material Decontaminated by Low Flow, High Pressure, Hot Water Washing

With the exception of equipment and piping and the washwater trough within the Explosives Washout Plant that may have potentially contained elevated explosive concentrations, open surfaces were likely to have had low explosive concentrations resulting from dust or incidental airborne explosive contamination. Although the available data were limited during design, the available analytical results confirmed that concentrations on open surfaces were generally low and were not a significant risk to human health.

Open surfaces that were potentially contaminated with explosives were decontaminated by low flow, high pressure, hot water washing to 5X U.S. Army status. The materials treated included:

- Aluminum siding and roofing in pelletizer building and shed
- Steel siding and roofing in the washout building
- 12-inch by 6-inch I-beams and trusses in the washout building
- Electrical equipment
- Steam piping, hot water tanks, stairs, platforms, and chutes outside of the Explosives Washout Plant
- Overhead hydraulic crane equipment

After treatment was completed and the surfaces dried, the Webster's Reagent Test was used to verify that surfaces of the building materials previously listed are decontaminated. The Webster's Reagent Test was used to identify systematic treatment problems and specific areas that were not sufficiently decontaminated. Webster's Reagent was applied to the test area using a squirt bottle. The test spot was neutralized by flushing the area with water to minimize damage to skin or clothing of the workers. If the Webster's Reagent Test resulted in any color change, decontamination was considered not achieved and the area was treated again. The

Webster's Reagent test was not applied to surfaces that were painted red. After verification indicated that treatment was complete, decontamination was certified with wipe samples analyzed with EPA Methods 8510 and 8515.

The required frequency of verification and certification testing for the various materials treated by low flow, high pressure, hot water washing is provided in Table 1. The frequency of testing specified was based on the degree of contamination expected and the degree of difficulty in cleaning the material. For all materials, except the overhead hydraulic crane assembly, Webster's Reagent was applied at a rate of approximately 1 sample per every 100 square feet (sf) of material treated, and wipe samples for analysis by EPA Methods 8510 and EPA 8515 were collected at an approximate rate between 1 per 500 to 1,000 sf. Because of the number of joints, crevices, and moveable components on the overhead crane assembly, testing of this equipment had the highest frequency at approximately 1 sample per 25 sf and 100 sf for verification and certification testing, respectively.

Building Material Treated by Flaming

Nonporous building materials, equipment, and piping in which the entire surface area of the material would have been labor intensive to inspect was pretreated with a low flow, high pressure water hot washing to remove residual explosive contamination. After pretreatment was complete, these materials were thermally treated with flaming by open burning. Flaming involved subjecting the contaminated equipment and piping to fire and high temperatures until residual explosive contamination is decomposed or volatilized.

Verification of treatment was performed using both visual inspection and Certipaks. Visual inspection included examining the surface material for burn marks. If visual inspection or Certipaks indicated that some materials were not completely treated, flaming was repeated on these materials. After verification indicated that treatment was complete, decontamination was certified with wipe samples collected from internal surfaces and analyzed with EPA Method 8330.

The colorimetric field tests were not specified to be used to certify decontamination of material treated by flaming because the burned material could have potentially caused interference with these colorimetric tests. Qualitative colorimetric tests, such as Webster's Reagent Test, was not specified for this project because the interior surfaces of the equipment and piping were the most likely to be contaminated and the most difficult areas to decontaminate. Therefore, a more accurate analytical method was specified.

Certipaks were placed throughout the treatment volume on the interior of equipment, ducting, and piping. Approximately, 1 Certipak was placed per 27 cubic feet (cf) or 1 cubic yard (cy) of material. Assuming a cube, this represents a surface area of 54 sf (or two times the surface area) for materials cleaned by low flow, high pressure, hot water washing. At a minimum, one or more Certipaks was placed inside each piece of equipment. If a Certipak could not be placed on an interior surface, it was be placed in an area that was considered difficult to heat because of location or metal thickness. Each Certipak was attached to a steel wire which was used to locate the Certipak after treatment. If the Certipak tested positive for explosives, the entire treatment volume (27 cf) was retreated and tested with another Certipak.

Certification of decontamination was achieved by analyzing wipe samples with EPA Method 8330 at a rate of 1 certification sample per 5 verification samples (or 20 percent). Each wipe sample was intended to certify that the treatment volume (approximately 135 cf or 5 cy) surrounding it had been decontaminated. Wipe samples were collected from interior surfaces that were most likely to have been contaminated prior to treatment and are difficult to treat.

One certification was obtained per five verification samples (or 20 percent). If the analytical results confirmed that residual concentrations greater than the cleanup standards were present, the entire treatment volume (135 cf) were required to be retreated. At least one sample was collected from each of the 14 pieces of equipment. In addition, one sample was collected from each of the following items: the eductor line, condensate line, and trough.

FIELD IMPLEMENTATION

Decontamination and demolition of the Explosives Washout Plant was conducted in 1996. The field methods (Webster's Reagent, EPA Method 8510, EPA Method 8515, and the Certipaks) were found to be easy to use and reliable. No retreatment was required after the field verification tests indicated that the material was clean. In every case where the verification field tests indicated that the material was clean, the certification tests confirmed it.

The Webster's Reagent Test provided color reactions as indicated in the field test description. The material tested was relatively uncontaminated to begin with, and there were only a few positive hits for explosives from the Webster's Reagent Test (Watkins 1997).

The remediation Contractor for the Phase I explosives soils remediation indicated that EPA Methods 8510 and 8515 were easy and relatively fast to use in the field and provided reliable quantitative results. However, in conducting the wipe samples for equipment certification, yellow paint from the equipment was extracted on to the wipe and was suspected to have resulted in some false positive results (Liikala 1995).

For the Certipaks, there was some variance in the color reactions from the test description. If TNT was present, the Certipaks were to change to blue and if not present, be clear. What was found in the field was variation of colors. TNT was taken to be present if the Certipak showed orange, red, reddish purple, or purple. If the Certipak was a pale yellow, TNT was taken not to be present. There was no detection of explosive in wipe samples analyzed using Method 8330 conducted after the Certipaks were pale yellow.

Finally, there was some difficulty initially encountered in placing the Certipaks. First, there was an attempt to place the Certipaks and document there placement as the material was being stacked in a pile for open burning. However, as the material was being stacked , the pile would move. Certipak placement was successfully accomplished after all the material was stacked for a flaming event. This was done typically with two people, one person in a boom truck, while the other person documented the locations (Watkins 1997).

ACKNOWLEDGMENT

The authors would like to provide a special thanks to Mr. Bob Watkins of ICF Kaiser Engineers, Inc., the Project Manager for the decontamination and demolition of the Explosives Washout Plant at UMCD, for his input on the field implementation of the verification and certification sampling and analysis program.

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